Basic Modeling With Simple Examples

Frank McKenna
UC Berkeley

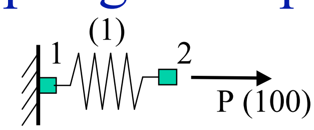
OpenSees Days 2011

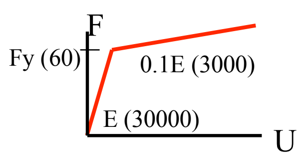
http://opensees.berkeley.edu/wiki/index.php/OpenSeesDays2011

NEES NEEScomm

Spring Example - Load Control

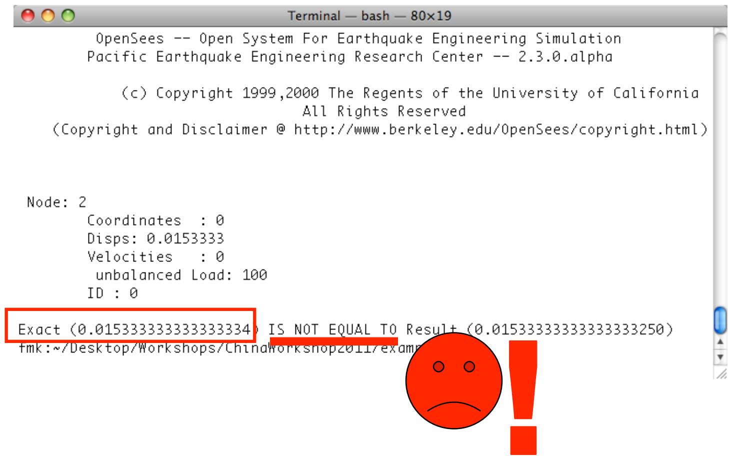
a.tcl





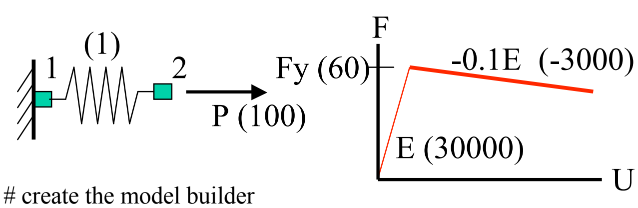

```
# create the model builder
model Basic -ndm 1 -ndf 1
# create 2 nodes
node 1 0.0
node 2 0.0
# fix node 1
fix 1 1
# create material
set Fy 60.0
set E 30000.0
set b 0.1
uniaxialMaterial Steel01 1 $Fy $E $b
# create element
element zeroLength 1 1 2 -mat 1 -dir 1
# create time series and load pattern
set P 100.0
timeSeries Linear 1
pattern Plain 1 1 {
  load 2 $P
}
```

```
# create an analysis
constraints Plain
numberer RCM
test NormDispIncr 1.0e-6 6 0
algorithm Newton
system ProfileSPD
integrator LoadControl 0.1
analysis Static
# perform the analysis
analyze 10
# Output
print node 2
set exact [expr $Fy/$E + (100-$Fy)/($b*$E)]
set res [lindex [nodeDisp 2] 0]
if {$exact == $res} {
   puts "Exact ($exact) EQUALS Result ($res)"
} else {
   puts "Exact ($exact) NOT EQUAL Result ($res)"
}
```

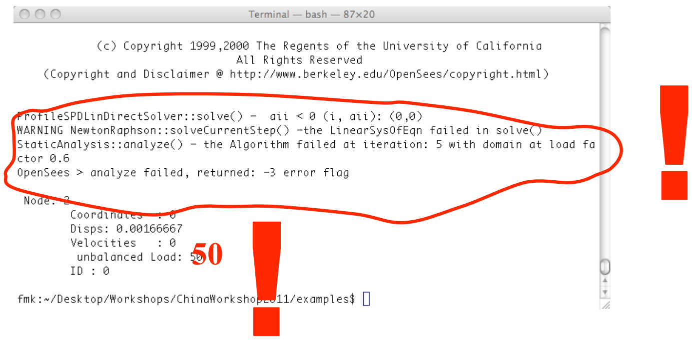


Computers cannot represent all numbers exactly
and
Computer math involves roundoff

b.tcl



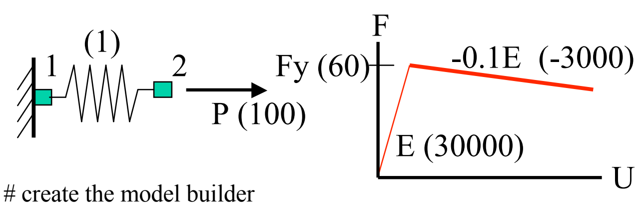

```
# create the model builder
model Basic -ndm 1 -ndf 1
# create 2 nodes
node 1 0.0
node 2 0.0
# fix node 1
fix 1 1
# create material
set Fy 60.0
set E 30000.0
set b -0.1
uniaxialMaterial Steel01 1 $Fy $E $b
# create element
element zeroLength 1 1 2 -mat 1 -dir 1
# create time series and load pattern
set P 100.0
timeSeries Linear 1
pattern Plain 1 1 {
  load 2 $P
}

# create an analysis
constraints Plain
numberer RCM
test NormDispIncr 1.0e-6 6 0
algorithm Newton
system ProfileSPD
integrator LoadControl 0.1
analysis Static
# perform the analysis
analyze 10
# Output
print node 2
```



change **system ProfileSPD** to **system BandGen**

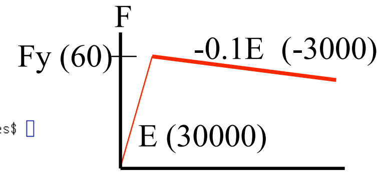
change **LoadControl 0.1** to **LoadControl 0.0999999**

c.tcl




```
# create the model builder
model Basic -ndm 1 -ndf 1
# create 2 nodes
node 1 0.0
node 2 0.0
# fix node 1
fix 1 1
# create material
set Fy 60.0
set E 30000.0
set b -0.1
uniaxialMaterial Steel01 1 $Fy $E $b
# create element
element zeroLength 1 1 2 -mat 1 -dir 1
# create time series and load pattern
set P 100.0
timeSeries Linear 1
pattern Plain 1 1 {
  load 2 $P
}

# create an analysis
constraints Plain
numberer RCM
test NormDispIncr 1.0e-6 6 0
algorithm Newton
system BandGen
integrator LoadControl 0.09999
analysis Static
# perform the analysis
analyze 10
# Output
print node 2
```

```
Terminal — bash — 104×22
        OpenSees -- Open System For Earthquake Engineering Simulation
       Pacific Earthquake Engineering Research Center -- 2.3.0.alpha

           (c) Copyright 1999,2000 The Regents of the University of California
                                 All Rights Reserved
    (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)


WARNING: CTestNormDispIncr::test() - failed to converge
after: 6 iterations
NewtnRaphson::solveCurrentStep() -the ConvergenceTest object failed in test()
StaticAnalysis::analyze() - the Algorithm failed at iteration: 6 with domain at load factor 0.7
OpenSees > analyze failed, returned: -3 error flag

 Node: 2
        Coordinates  : 0
        Disps: 0.002
        Velocities   : 0
         unbalanced Load: 60
        ID : 0

fmk:~/Desktop/Workshops/ChinaWorkshop2011/examples$
```

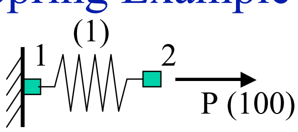


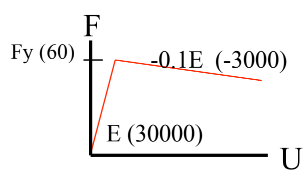
With a Yield Strength of 60
This is as far as we can push the
Model using LoadControl

We can go further using a Displacement Control scheme

Spring Example - Displacement Control

d.tcl





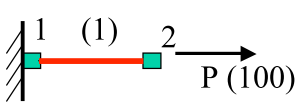

```
# create the model builder
model Basic -ndm 1 -ndf 1
# create 2 nodes
node 1 0.0
node 2 0.0
# fix node 1
fix 1 1
# create material
set Fy 60.0
set E 30000.0
set b -0.1
uniaxialMaterial Steel01 1 $Fy $E $b
# create element
element zeroLength 1 1 2 -mat 1 -dir 1
# create time series and load pattern
set P 100.0
timeSeries Linear 1
pattern Plain 1 1 {
  load 2 $P
}
```

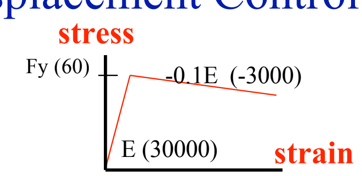
```
# create an analysis
constraints Plain
numberer RCM
test NormDispIncr 1.0e-12 6 0
algorithm Newton
system BandGen
integrator DisplacementControl 2 1 0.001
analysis Static
# perform the analysis & print results
for {set i 0} {$i < 10} {incr i 1} {
    analyze 1
    set factor [getTime]
    puts "[expr $factor*$P]  [lindex [nodeDisp 2] 0]"
}

print node 2
```

```
Terminal — bash — 92x30
fmk:~/Desktop/Workshops/ChinaWorkshop2011/examples$ OpenSees d.tcl


         OpenSees -- Open System For Earthquake Engineering Simulation
        Pacific Earthquake Engineering Research Center -- 2.3.0.alpha

            (c) Copyright 1999,2000 The Regents of the University of California
                                 All Rights Reserved
    (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)


30.0  0.0010000000000000002
60.0  0.0020000000000000004
56.99999999999999  0.0030000000000000006
54.0  0.0040000000000000008
51.0  0.0050000000000000010
48.0  0.0060000000000000012
45.0  0.0070000000000000015
42.0  0.0080000000000000017
39.0  0.0090000000000000105
36.0  0.0100000000000000194

 Node: 2
        Coordinates  : 0
        Disps: 0.01
        Velocities   : 0
         unbalanced Load: 36
        ID : 0

fmk:~/Desktop/Workshops/ChinaWorkshop2011/examples$
```

Truss Example - Displacement Control

e.tcl





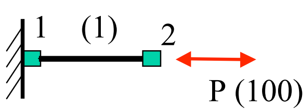

```
# create the model builder
model Basic -ndm 1 -ndf 1
# create 2 nodes
node 1 0.0
node 2 1.0
# fix node 1
fix 1 1
# create material
set Fy 60.0
set E 30000.0
set b -0.1
uniaxialMaterial Steel01 1 $Fy $E $b
# create element
set A 1.0
element Truss 1 1 2 $A 1
# create time series and load pattern
set P 100.0
timeSeries Linear 1
pattern Plain 1 1 {
  load 2 $P
}
```

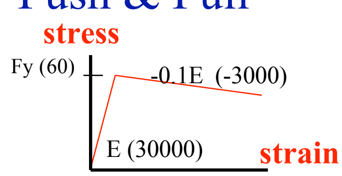
```
# create an analysis
constraints Plain
numberer RCM
test NormDispIncr 1.0e-12 6 0
algorithm Newton
system BandGen
integrator DisplacementControl 2 1 0.001
analysis Static

# perform the analysis & print results
for {set i 0} {$i < 10} {incr i 1} {
   analyze 1
   set factor [getTime]
   puts "[expr $factor*$P]  [lindex [nodeDisp 2] 0]"
}

print node 2
```

```
Terminal — bash — 92×30
fmk:~/Desktop/Workshops/ChinaWorkshop2011/examples$ OpenSees e.tcl


         OpenSees -- Open System For Earthquake Engineering Simulation
        Pacific Earthquake Engineering Research Center -- 2.3.0.alpha

            (c) Copyright 1999,2000 The Regents of the University of California
                                 All Rights Reserved
    (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)


30.0  0.0010000000000000002
60.0  0.0020000000000000004
56.99999999999999  0.0030000000000000006
54.0  0.0040000000000000008
51.0  0.0050000000000000010
48.0  0.0060000000000000012
45.0  0.0070000000000000015
42.0  0.0080000000000000017
39.0  0.0090000000000000105
36.0  0.0100000000000000194

 Node: 2
        Coordinates  : 1
        Disps: 0.01
        Velocities   : 0
         unbalanced Load: 36
        ID : 0

fmk:~/Desktop/Workshops/ChinaWorkshop2011/examples$
```

Truss Example - Push & Pull

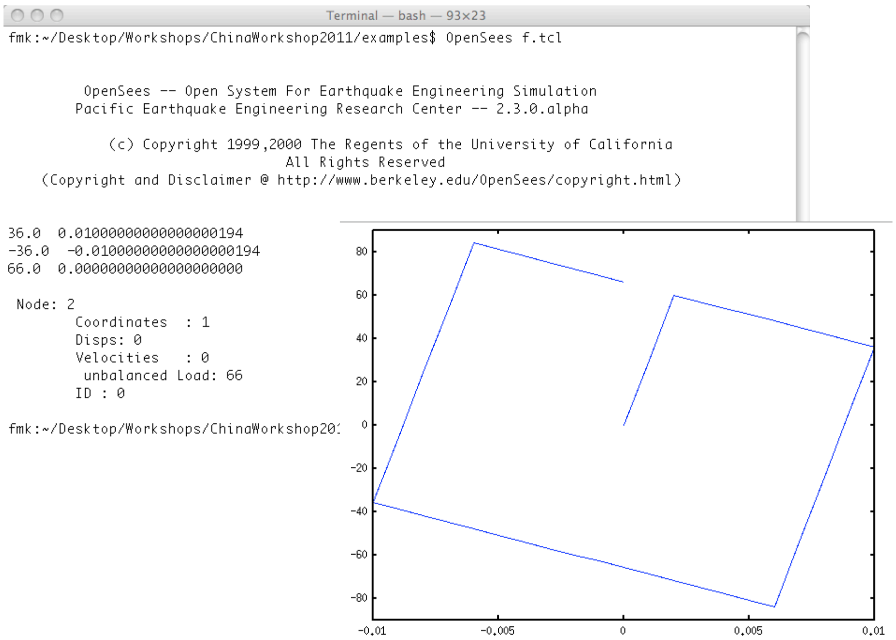
f.tcl





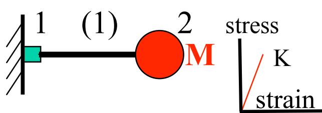

```
# create the model builder
model Basic -ndm 1 -ndf 1
# create 2 nodes
node 1 0.0
node 2 1.0
# fix node 1
fix 1 1
# create material
set Fy 60.0
set E 30000.0
set b -0.1
uniaxialMaterial Steel01 1 $Fy $E $b
# create element
set A 1.0
element Truss 1 1 2 $A 1
# create time series and load pattern
set P 100.0
timeSeries Linear 1
pattern Plain 1 1 {
  load 2 $P
}
```

```
# create an analysis
constraints Plain
numberer RCM
test NormDispIncr 1.0e-12 6 0
algorithm Newton
system BandGen
integrator DisplacementControl 2 1 0.001
analysis Static
# perform the analysis & print results
foreach {$numIter $dU} {10 0.001 20 -0.001 10 0.001} {
  integrator DisplacementControl 2 1 0.001
  analyze $numIter
  set factor [getTime]
  puts "[expr $factor*$P]  [lindex [nodeDisp 2] 0]"
}

print node 2
```



Truss Example - Uniform Excitation

j.tcl




```
# set some variables
set Tn 1.0
set K 4.0
set dampR 0.02
#set some constants
set g 386.4
set PI [expr 2.0 * asin(1.0)]
#derived quantaties
set Wn [expr 2.0 * $PI / $Tn]
set M [expr $K / ($Wn * $Wn)]
set c [expr 2.0*$M*$Wn*$dampR]

# create the model
model basic -ndm 1 -ndf 1
node  1      0.0
node  2      1.0  -mass $M
fix 1 1
uniaxialMaterial  Elastic  1 $K 0.0
uniaxialMaterial  Elastic  2 0.0 $c
uniaxialMaterial  Parallel 3 1 2

element truss 1 1 2 1.0 3
set dT 0.0;
set nPts 0;
```

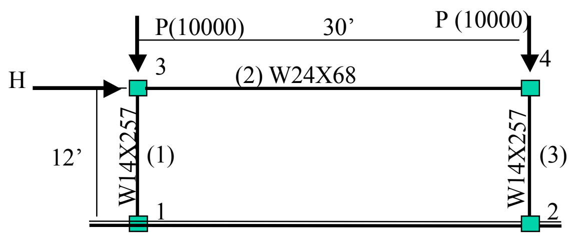
```
# create the uniform excitation pattern
set record el_centro
source ReadRecord.tcl
ReadRecord $record.AT2  $record.dat dT nPts
timeSeries Path 1 -filePath $record.dat -dt $dT -factor $
pattern UniformExcitation  1 1 -accel 1
# create the analysis
constraints Plain
integrator Newmark 0.5 [expr 1.0/6.0]
system ProfileSPD
test NormUnbalance 1.0e-12  6 0
algorithm Newton
numberer RCM
analysis Transient
# perform analysis
set t 0.0; set ok 0.0; set maxD 0.0;
set maxT [expr (1+$nPts)*$dT];
while {$ok == 0 && $t < $maxT} {
    set ok [analyze 1 $dT]
    set t [getTime]
    set d [nodeDisp 2 1]
    if {$d > $maxD} {
        set maxD $d
    } elseif {$d < [expr -$maxD]} {
        set maxD [expr -$d]
    }
}
puts "record: $record period: $Tn damping ratio: $dampR  r
```

Terminal — bash — 81×13

```
examples> OpenSees j.tcl


         OpenSees -- Open System For Earthquake Engineering Simulation
        Pacific Earthquake Engineering Research Center -- 2.3.0.alpha

            (c) Copyright 1999,2000 The Regents of the University of California
                                 All Rights Reserved
    (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)


record: el_centro period: 1.0 damping ratio: 0.02  max disp: 5.962305018001343
examples> 
```

Elastic Portal Frame - Pushover

g.tcl

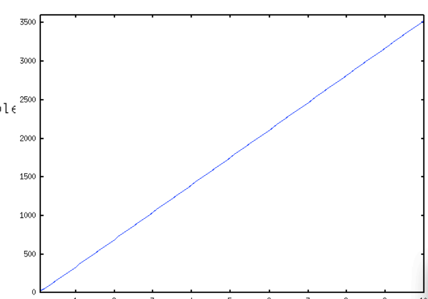



```
# create the model builder
model Basic -ndm 2 -ndf 3

# create 2 nodes
node 1   0.0   0.0
node 2 360.0   0.0
node 3   0.0 144.0
node 4 360.0 144.0

# fix node 1
fix 1 1 1 1
fix 2 1 1 1

geomTransf Linear 1
geomTransf Linear 2

# create elements
source SteelWSections.tcl
set in 1.0
set E 30000
ElasticBeamWSection2d 1 1 3 W14X257 $E 1
ElasticBeamWSection2d 2 3 4  W24X68  $E 2
ElasticBeamWSection2d 3 2 4 W14X257 $E 1

# create time series and load pattern
set P 10000.0
timeSeries Constant 1
pattern Plain 1 1 {
  load 3 0.0 -$P 0.0
  load 4 0.0 -$P 0.0
}

# create an analysis
constraints Plain
numberer RCM
test NormDispIncr 1.0e-12 6 0
algorithm Newton
system ProfileSPD
integrator LoadControl 1.0
analysis Static

# perform the analysis
analyze 1

timeSeries Linear 2
pattern Plain 2 2 {
  load 3 1.0 0.0 0.0
  load 4 1.0 0.0 0.0
}
integrator DisplacementControl 3 1 0.1
analyze 100; print node 3
```

SteelWSections.tcl

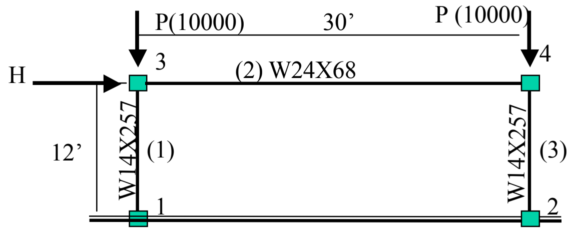
```
proc ElasticBeamWSection2d {eleTag iNode jNode sectType E transfTag {Orient XX}} {
  global WSection
  global in
  set found 0
  foreach {section prop} [array get WSection $sectType] {
    set propList [split $prop]
    set A [expr [lindex $propList 0]*$in*$in]
    set Ixx [expr [lindex $propList 5]*$in*$in*$in*$in]
    set Iyy [expr [lindex $propList 6]*$in*$in*$in*$in]
    if {$Orient == "YY" } {
      puts "element elasticBeamColumn $eleTag $iNode $jNode $A $E $Iyy $transfTag"
      element elasticBeamColumn $eleTag $iNode $jNode $A $E $Iyy $transfTag
    } else {
      puts "element elasticBeamColumn $eleTag $iNode $jNode $A $E $Ixx $transfTag"
      element elasticBeamColumn $eleTag $iNode $jNode $A $E $Ixx $transfTag
    }
  }
}
#Winxlb/f "Area(in2) d(in) bf(in) tw(in) tf(in) Ixx(in4) Iyy(in4)"
array set WSection {
  W44X335    "98.5 44.0 15.9 1.03 1.77 31100 1200 74.7"
  W44X290    "85.4 43.6 15.8 0.865 1.58 27000 1040 50.9"
  W44X262    "76.9 43.3 15.8 0.785 1.42 24100 923 37.3"
  W44X230    "67.7 42.9 15.8 0.710 1.22 20800 796 24.9"
  W40X593    "174 43.0 16.7 1.79 3.23 50400 2520 445"
  W40X503    "148 42.1 16.4 1.54 2.76 41600 2040 277"
```

```
Terminal — bash — 101×22
fmk:~/Desktop/Workshops/ChinaWorkshop2011/examples$ OpenSees g.tcl


         OpenSees -- Open System For Earthquake Engineering Simulation
        Pacific Earthquake Engineering Research Center -- 2.3.0.alpha

            (c) Copyright 1999,2000 The Regents of the University of California
                                 All Rights Reserved
    (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)


element elasticBeamColumn 1 1 3 75.6 30000 3400.0 1
element elasticBeamColumn 2 3 4 20.1 30000 1830.0 2
element elasticBeamColumn 3 2 4 75.6 30000 3400.0 1

 Node: 3
        Coordinates  : 0 144
        Disps: 10 -0.609542 -0.0787731
         unbalanced Load: 1765.38 -10000 0
        ID : 3 4 5

fmk:~/Desktop/Workshops/ChinaWorkshop2011/example
```



Elastic Portal Frame - Pushover

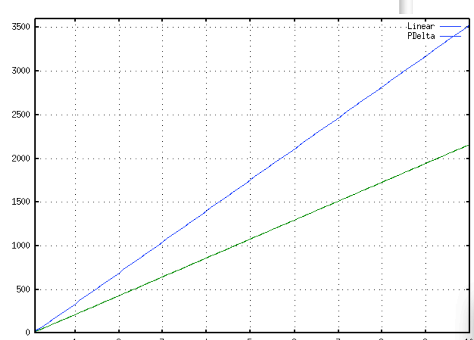
h.tcl




```
# create the model builder
model Basic -ndm 2 -ndf 3

# create 2 nodes
node 1   0.0   0.0
node 2 360.0   0.0
node 3   0.0 144.0
node 4 360.0 144.0

# fix node 1
fix 1 1 1 1
fix 2 1 1 1

geomTransf PDelta 1
geomTransf Linear 2

# create elements
source SteelWSections.tcl
set in 1.0
set E 30000
ElasticBeamWSection2d 1 1 3 W14X257 $E 1
ElasticBeamWSection2d 2 3 4  W24X68  $E 2
ElasticBeamWSection2d 3 2 4 W14X257 $E 1

# create time series and load pattern
set P 10000.0
timeSeries Constant 1
pattern Plain 1 1 {
   load 3 0.0 -$P 0.0
   load 4 0.0 -$P 0.0
}

# create an analysis
constraints Plain
numberer RCM
test NormDispIncr 1.0e-12 6 0
algorithm Newton
system ProfileSPD
integrator LoadControl 1.0
analysis Static

# perform the analysis
analyze 1

timeSeries Linear 2
pattern Plain 2 2 {
   load 3 1.0 0.0 0.0
   load 4 1.0 0.0 0.0
}
integrator DisplacementControl 3 1 0.1
analyze 100; print node 3
```

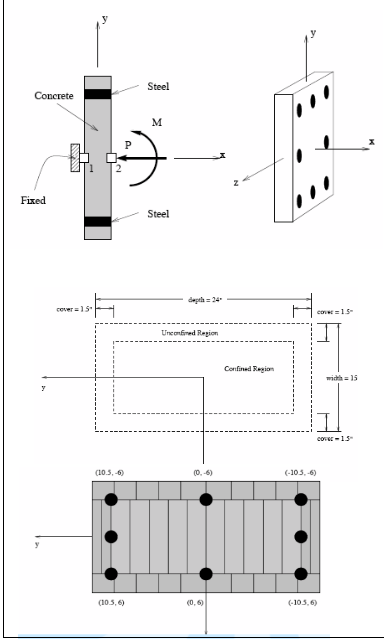
Terminal — bash — 101×22

```
fmk:~/Desktop/Workshops/ChinaWorkshop2011/examples$ OpenSees h.tcl


         OpenSees -- Open System For Earthquake Engineering Simulation
        Pacific Earthquake Engineering Research Center -- 2.3.0.alpha

            (c) Copyright 1999,2000 The Regents of the University of California
                                 All Rights Reserved
    (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)


element elasticBeamColumn 1 1 3 75.6 30000 3400.0 1
element elasticBeamColumn 2 3 4 20.1 30000 1830.0 2
element elasticBeamColumn 3 2 4 75.6 30000 3400.0 1

 Node: 3
        Coordinates  : 0 144
        Disps: 10 -0.609521 -0.0787607
         unbalanced Load: 1080.3 -10000 0
        ID : 3 4 5

fmk:~/Desktop/Workshops/ChinaWorkshop2011/examples$
```



Moment Curvature Example

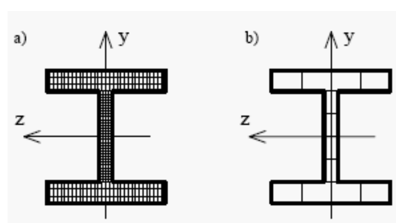
m.tcl

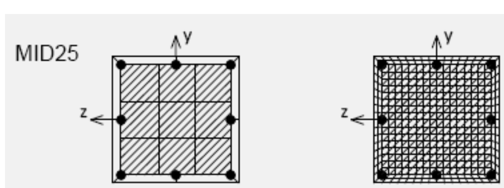



```
model Basic -ndm 2 -ndf 3

# Define materials 1) confined, 2) unconfined, 3 steel
uniaxialMaterial Concrete01  1  -6.0  -0.004   -5.0     -0.014
uniaxialMaterial Concrete01  2  -5.0   -0.002   0.0     -0.006
set fy 60.0;      # Yield stress
set E 30000.0;    # Young's modulus
uniaxialMaterial Steel01  3  $fy $E 0.01

# set some paramaters
set width 15
set depth 24
set cover  1.5
set As    0.60;    # area of no. 7 bars
source RCsection2D.tcl
RCsection2D 1 $depth $width $cover 1 2 3 3 1 $As \
     10 10 2

# Estimate yield curvature
# (Assuming no axial load and only top and bottom steel)
set d [expr $depth-$cover]      ;# d -- from cover to rebar
set epsy [expr $fy/$E]   ;# steel yield strain
set Ky [expr $epsy/(0.7*$d)]

# Print estimate to standard output
puts "Estimated yield curvature: $Ky"
set P -180;             # axial load
set mu 15;              # Target ductility for analysis
set numIncr 100;     # Number of analysis increments
# Call the section analysis procedure
source MomentCurvature.tcl
MomentCurvature 1 $P [expr $Ky*$mu] $numIncr
```

HOW TO MODEL FIBER SECTIONS

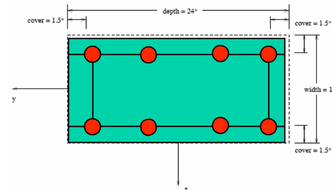
```
section Fiber $secTag {
        fiber <fiber arguments>
        patch <patch arguments>
        layer <layer arguments>
}
```





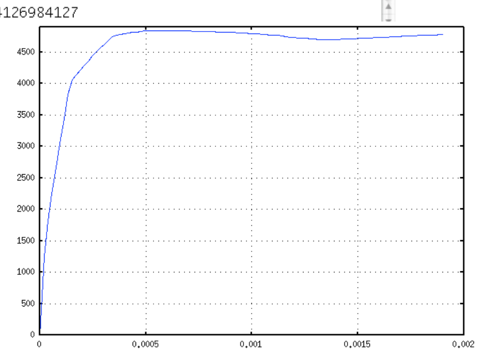
RCsection2D.tcl

RCsection2D.tcl



```
proc RCsection2D {id h b cover coreID coverID steelID numBarsTB numBarsS barArea nfCore nfCoverS
     nfCoverTB} {

  # some variables derived from the parameters
  set y1 [expr $h/2.0]
  set z1 [expr $b/2.0]
  set As $barArea

  section Fiber 1 {
     # Create the concrete core fibers
     patch rect $coreID $nfCore 1 [expr $cover-$y1] [expr $cover-$z1] [expr $y1-$cover] [expr $z1-
     $cover]

     # Create the concrete cover fibers (top, bottom, left, right)
     patch rect $coverID $nfCoverS  1    [expr -$y1]   [expr $z1-$cover]    $y1           $z1
     patch rect $coverID $nfCoverS  1    [expr -$y1]     [expr -$z1]      $y1        [expr $cover-$z1]
     patch rect $coverID $nfCoverTB 1    [expr -$y1]    [expr $cover-$z1] [expr $cover-$y1] [expr $z1-
     $cover]
     patch rect $coverID $nfCoverTB 1  [expr $y1-$cover] [expr $cover-$z1]     $y1        [expr $z1-
     $cover]

     # Create the reinforcing fibers (left, middle, right)
     layer straight $steelID $numBarsTB  $As [expr $y1-$cover] [expr $z1-$cover] [expr $y1-$cover]
     [expr $cover-$z1]
     layer straight $steelID $numBarsTB  $As [expr $cover-$y1] [expr $z1-$cover] [expr $cover-$y1]
     [expr $cover-$z1]
     layer straight $steelID $numBarsS $As [expr $y1-$cover] [expr $z1-$cover] [expr $cover-$y1] [expr
     $cover-$z1]
     layer straight $steelID $numBarsS $As [expr $y1-$cover] [expr $cover-$z1] [expr $cover-$y1] [expr
     $z1-$cover]
  }
}
```

```
Terminal — bash — 82×13
examples> OpenSees m.tcl


        OpenSees -- Open System For Earthquake Engineering Simulation
       Pacific Earthquake Engineering Research Center -- 2.3.0.alpha

            (c) Copyright 1999,2000 The Regents of the University of California
                              All Rights Reserved
    (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)


Estimated yield curvature: 0.000126984126984127
examples> 
```



Simply Supported Beam

n.tcl

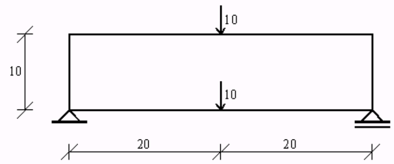


Fig. 1 Geometry and static loads

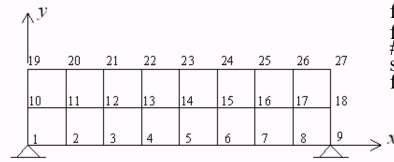


Fig. 2 Finite element mesh and node numbering

```
# some problem parameters
set L 40.0
set H 10.0
set thick 2.0
set P 10
set nX 9; # numNodes x dirn
set nY 3; # numNodes y dirn
# model builder
model Basic -ndm 2 -ndf 2
# create material
nDMaterial ElasticIsotropic 1 1000 0.25  3.0
```

```
# create nodes
set nodeTag 1
set yLoc 0.0;
for {set i 0} {$i < $nY} {incr i 1} {
    set xLoc 0.0;
    for {set j 0} {$j < $nX} {incr j 1} {
        node $nodeTag $xLoc $yLoc
        set xLoc [expr $xLoc+ $L/($nX-1.0)]
        incr nodeTag
    }
    set yLoc [expr $yLoc+ $H/($nY-1.0)]
}
# boundary conditions
fix  1  1 1
fix $nX 1 1
# create elements
set eleTag 1
for {set i 1} {$i < $nY} {incr i 1} {
    set iNode [expr 1+($i-1)*$nX];
    set jNode [expr $iNode+1];
    set kNode [expr $jNode+$nX]
    set lNode [expr $iNode+$nX]
    for {set j 1} {$j < $nX} {incr j 1}
        element quad $eleTag $iNode $jNode $kNode $lNode \
             $thick "PlaneStress" 1
        incr eleTag; incr iNode; incr jNode; incr kNode; incr lN
    }
}
# apply loads
set midNode [expr ($nX+1)/2]
timeSeries Linear 1
pattern Plain 1 1 {
    load $midNode 0 -$P
    load [expr $midNode + $nX*($nY-1)] 0 -$P
}
analysis Static;
analyze 1; print node $midNode
```

Simply Supported Beam

o.tcl

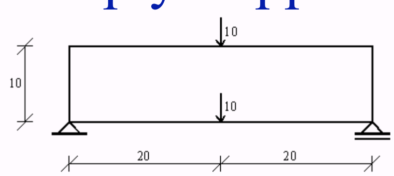


Fig. 1 Geometry and static loads

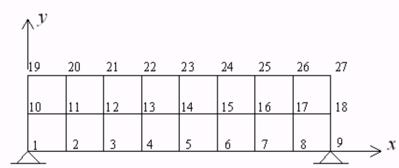


Fig. 2 Finite element mesh and node numbering

```
# some problem parameters
set L 40.0
set H 10.0
set thick 2.0
set P 10
set nX 9; # numNodes x dirn
set nY 3; # numNodes y dirn

# model builder
model Basic -ndm 2 -ndf 2

# create material
nDMaterial ElasticIsotropic 1 1000 0.25  3.0
```

```
# use block command
set cmd "block2D [expr $nX-1] [expr $nY-1] 1 1 \
    quad \" $thick PlaneStress 1\" {
        1   0   0
        2  $L   0
        3  $L  $H
        4   0  $H
}"

eval $cmd

# apply loads
set midNode [expr ($nX+1)/2]
timeSeries Linear 1
pattern Plain 1 1 {
    load $midNode 0 -$P
    load [expr $midNode + $nX*($nY-1)] 0 -$P
}
analysis Static;
analyze 1;
print node $midNode
```

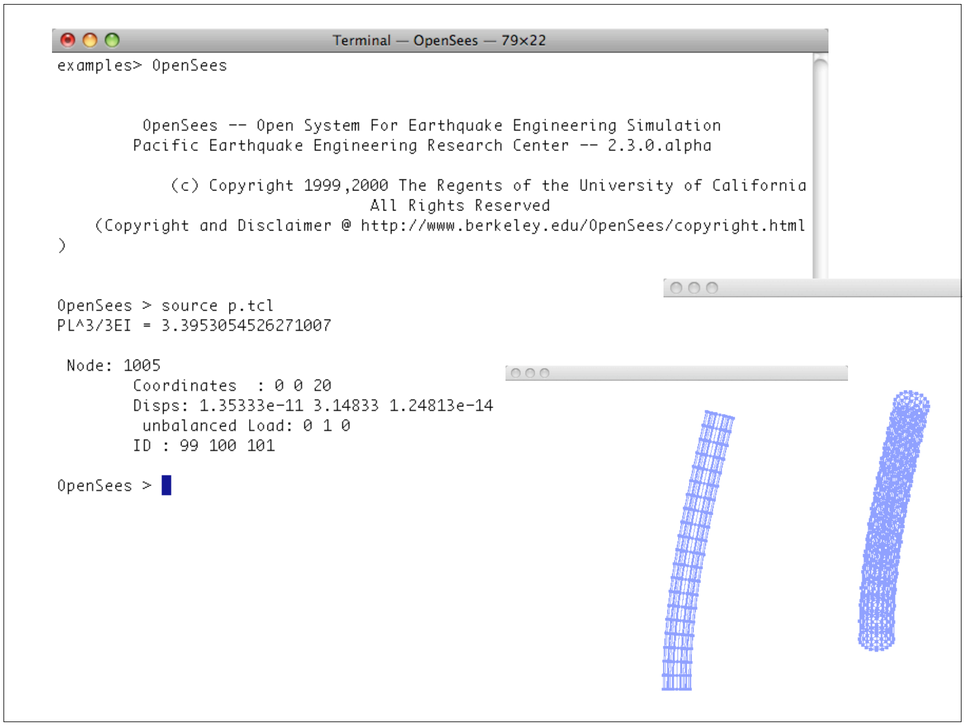
```
Terminal — bash — 85x37
examples> OpenSees n.tcl


         OpenSees -- Open System For Earthquake Engineering Simulation
        Pacific Earthquake Engineering Research Center -- 2.3.0.alpha

             (c) Copyright 1999,2000 The Regents of the University of California
                                 All Rights Reserved
    (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)



 Node: 5
        Coordinates  : 20 0
        Disps: -1.37853e-16 -0.096041
         unbalanced Load: 0 -10
        ID : 26 27

examples> OpenSees o.tcl


         OpenSees -- Open System For Earthquake Engineering Simulation
        Pacific Earthquake Engineering Research Center -- 2.3.0.alpha

             (c) Copyright 1999,2000 The Regents of the University of California
                                 All Rights Reserved
    (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)



 Node: 5
        Coordinates  : 20 0
        Disps: -1.37853e-16 -0.096041
         unbalanced Load: 0 -10
        ID : 26 27

examples> 
```

Cantilevered Circular Column

p.tcl

```
set P 1.0
set L 20.0
set R 1.0
set E 1000.0
set nz  20
set nx  6
set ny  6
set PI [expr 2.0 * asin(1.0)]
set I  [expr $PI*pow((2*$R),4)/64.0]
puts "PL^3/3EI = [expr $P*pow($L,3)/(3.0*$E*$I)

# Create ModelBuilder with 3 dimensions and 6 D
model Basic -ndm 3 -ndf 3

# create the material
nDMaterial ElasticIsotropic   1   $E   0.25  1.27

set eleArgs "1"
set element bbarBrick

set nn [expr ($nz)*($nx+1)*($ny+1) + (($nx+1)*(
set n1 [expr ($nz)*($nx+1)*($ny+1) +$nx]
```

```
# mesh generation
set sqrtR [expr sqrt($R/2.0)]
set cmd "block3D $nx $ny $nz   1 1  $el
     1  -$sqrtR    -$sqrtR     0
     2   $sqrtR    -$sqrtR     0
     3   $sqrtR     $sqrtR     0
     4  -$sqrtR     $sqrtR     0
     5  -$sqrtR    -$sqrtR     $L
     6   $sqrtR    -$sqrtR     $L
     7   $sqrtR     $sqrtR     $L
     8  -$sqrtR     $sqrtR     $L
    13   0      -$R     0
    14   $R      0      0
    15   0       $R     0
    16  -$R      0      0
    18   0      -$R     $L
    19   $R      0      $L
    20   0       $R     $L
    21  -$R      0      $L
    23   0      -$R     [expr $L/2.0]
    24   $R      0      [expr $L/2.0]
    25   0       $R     [expr $L/2.0]
    26  -$R      0      [expr $L/2.0]
  }"
eval $cmd

# boundary conditions
fixZ 0.0   1 1 1

# Constant point load
pattern Plain 1 Linear {
   load $nn  0.0 $P 0.0
}
```



Any Questions?